NAVY
PROPOSAL SUBMISSION

INTRODUCTION:

The responsibility for the implementation, administration and management of the Navy STTR program is with the Office of Naval Research (ONR). The Navy STTR Program Manager is Mr. John Williams, (703) 696-0342, williajr@onr.navy.mil. If you have questions of a specific nature, contact Mr. Williams. For general inquiries or problems with the electronic submission, contact the DoD Help Desk at 866-SBIRHLP (724-7457). For technical questions about a topic, contact the Topic Authors listed under each topic only available on the website at **http://www.onr.navy.mil/sbir** under "Solicitation" before **01 March 2002.** After 1 March, you must use the SITIS system listed in section 1.5c at the front of the solicitation or go to the DoD website at **http://www.acq.osd.mil/sadbu/sbir** for more information.

PHASE I PROPOSAL SUBMISSION:

Read the DoD front section of this solicitation for detailed instructions on proposal format and program requirements. When you prepare your proposal, keep in mind that Phase I should address the feasibility of a solution to the topic. The Navy only accepts Phase I proposals with a base effort not exceeding $70,000 and with the option not exceeding $30,000. The technical period of performance for the Phase I should be 6 months to commence on or about 01 July 2002. The Phase I option should be 3 months and address the transition into the Phase II effort. Phase I options are typically only funded after the decision to fund the Phase II has been made. Phase I proposals, including the option, have a 25-page limit (see section 3.3). The Navy will evaluate and select Phase I proposals using scientific review criteria based upon technical merit and other criteria as discussed in this solicitation document. Due to limited funding, the Navy reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded. The Navy typically provides a firm fixed price contract or awards a small purchase agreement as a Phase I award.

NEW REQUIREMENT: ALL PROPOSAL SUBMISSIONS TO THE NAVY STTR PROGRAM MUST BE SUBMITTED ELECTRONICALLY

It is mandatory that the **entire** technical proposal, DoD Proposal Cover Sheet, Cost Proposal, and the Company Commercialization Report are submitted electronically through the DoD SBIR/STTR website at http://www.dodsbir.net/submission**.** This site will lead you through the process for submitting your technical proposal and all of the sections electronically each of these documents are submitted separately through the website. If you have any questions or problems with the electronic submission contact the DoD SBIR Helpdesk at 866-SBIRHLP (724-7457). Your proposal must be submitted via the submission site on or before the **3:00 p.m. EST, 17 April 2002 deadline. A hardcopy will NOT be required**. A signature by hand or electronically is not required when you submit your proposal over the Internet.

Acceptable Formats for Online Submission: All technical proposal files will be converted to Portable Document Format (PDF) for evaluation purposes; therefore, submissions may be received in PDF format but other acceptable formats are MS Word, WordPerfect, Text, Rich Text Format (RTF), and Adobe Acrobat. The Technical Proposal should include all graphics and attachments, but not include Cover Sheets or Cost Proposal as they are submitted separately. Technical Proposals should conform to the limitations on margins and number of pages specified in the front section of this DoD Solicitation. However, your Cost Proposal will only count as one page and your Cover Sheets will only count as two, no matter how they print out after being converted. Most proposals will be printed out on black and white printers so make sure all graphics are distinguishable in black and white. It is strongly encouraged that you perform a virus check on each submission to avoid complications or delays in downloading your Technical Proposal. To verify that your proposal has been received, click on the "Check Upload" icon to view your proposal. Typically, your proposal will be uploaded within the hour. However, if your proposal does not appear after an hour, please contact the DoD Help Desk. It is recommended that you submit early, as computer traffic gets heavy nearer the solicitation closing and slows down the system.

Within one week of the Solicitation closing, you will receive notification via e-mail that your proposal has been received and processed for evaluation by the Navy.

PHASE I ELECTRONIC SUMMARY REPORT:

All Phase I award winners must electronically submit a Phase I summary report through the Navy SBIR website at the end of their Phase I. The Phase I Summary Report is a non-proprietary summary of Phase I results. It should not exceed 700 words and should include potential applications and benefits. It should require minimal work from the contractor because most of this information is required in the final report. The summary of the final report will be submitted through the Navy SBIR/STTR website at: **http://www.onr.navy.mil/sbir**, click on "Submission", then click on "Submit a Phase I or II Summary Report".

ADDITIONAL NOTES:

1. The Small Business Administration (SBA) has made a determination that will permit the Naval Academy, the Navy Post Graduate School and the other military academies to participate as a Research Institution or subcontractor in the SBIR/STTR program, since they are institutions of higher learning.

2. The Navy will allow firms to include with their proposals, success stories that have been submitted through the Navy SBIR website at **http://www.onr.navy.mil/sbir**. A Navy success story is any follow-on funding that a firm has received based on technology developed from a Navy SBIR or STTR Phase II award. The success stories should be included as appendices to the proposal. These pages will not be counted towards the 25-page limit. The success story information will be used as part of the evaluation of the third criteria, Commercial Potential (listed in Section 4.2 of this solicitation) which includes the Company's Commercialization Report and the strategy described to commercialize the technology discussed in the proposal. The Navy is very interested in companies that transition SBIR/STTR efforts directly into Navy and DoD programs and/or weapon systems. If a firm has never received a Navy SBIR/STTR Phase II it will not count against them.

NAVY FAST TRACK DATES AND REQUIREMENTS:

The Fast Track application must be received by the Navy 150 days from the Phase I award start date. Your Phase II Proposal must be submitted within 180 days of the Phase I award start date. Any Fast Track applications or proposals not meeting these dates will be declined. All Fast Track applications and required information must be submitted online through the DoD Submission website **http://www.dodsbir.net/submission**, and mailed to the Navy STTR Program Manager at the address listed on the Navy SBIR/STTR website under POCs and to the designated Contracting Officer's Technical Monitor (the Technical Point of Contact (TPOC)) for the contract. The information required by the Navy, is the same as the information required under the DoD Fast Track described in the front part of this solicitation.

PHASE II PROPOSAL SUBMISSION:

Phase II is the demonstration of the technology that was found feasible in Phase I. Only those Phase I awardees which have been **invited** to submit a Phase II proposal by the proper point of contact, during or at the end of a successful Phase I effort will be eligible to participate for a Phase II award. If you have been invited to submit a Phase II proposal to the Navy, obtain a copy of the Phase II instructions from the Navy SBIR/STTR website. The Navy will also offer a "Fast Track" into Phase II to those companies that successfully obtain third party cash partnership funds ("Fast Track" is described in Section 4.5 of this solicitation). The Navy typically provides a cost plus fixed fee contract as a Phase II award. The type of award is at the discretion of the contracting officer.

Upon receiving an invitation, submission of a Phase II proposal should consist of three elements: 1) A base effort, which is the demonstration phase of the SBIR/STTR project; 2) A 2 to 5 page Transition/Marketing plan describing how, to whom and at what stage you will market and transition your technology to the government, government prime contractor, and/or private sector; and 3) At least one Phase II Option which would be a fully costed and well defined section describing a test and evaluation plan or further R&D. Phase II efforts are typically two (2) years and Phase II options are typically an additional six (6) months. Phase II proposals together with the Phase II Option are limited to 40 pages (unless otherwise directed by the TPOC or contract officer). All Phase II proposals must have a complete electronic submission. Complete electronic submission includes the submission of the Cover Sheets, Cost

Proposal, Company Commercialization Report, the **ENTIRE** technical proposal and any appendices via the DoD Submission site. The DoD proposal submission site **http://www.dodsbir.net/submission** will lead you through the process for submitting your technical proposal and all of the sections electronically. Each of these documents are submitted separately through the website. Your proposal must be submitted via the submission site on or before the specified deadline. The Navy Activity that invited your PH II may also require a hardcopy of your proposal.

All Phase II award winners must attend a one-day Commercialization Assistance Program (CAP) meeting typically held in the July to August time frame in the Washington D.C. area during the second year of the Phase II effort. If you receive a Phase II award, you will be contacted with more information regarding this program or you can visit **http://www.navysbir.com/cap**.

As with the Phase I award, Phase II award winners must electronically submit a Phase II summary report through the Navy SBIR website at the end of their Phase II. The Phase II Summary Report is a non-proprietary summary of Phase II results. It should not exceed 700 words and should include potential applications and benefit. It should require minimal work from the contractor because most of this information is required in the final report.

The Navy has adopted a New Phase II Enhancement Plan to encourage transition of Navy STTR funded technology to the Fleet. Since the Law (PL102-564) permits Phase III awards during Phase II work, the Navy will provide a 1 to 4 match of Phase II to Phase III funds that the company obtains from an acquisition program. Up to $250,000 in additional STTR funds for $1,000,000 match of acquisition program funding, can be provided as long as the Phase III is awarded and funded during the Phase II. If you have questions, please contact the Navy Activity POC.

Effective in Fiscal Year 2000, a Navy Activity will not issue a Navy STTR Phase II award to a company when the elapsed time between the completion of the Phase I award and the actual Phase II award date is eight (8) months or greater; unless the process and the award has been formally reviewed and approved by the Navy STTR Program Office. Also, any STTR Phase I contract that has been extended by a no cost extension beyond one (1) year will be ineligible for a Navy STTR Phase II award using STTR funds.

PHASE I PROPOSAL SUBMISSION CHECKLIST:

All of the following criteria must be met or your proposal will be REJECTED.

____1. Your complete STTR PH I proposal (coversheet, technical proposal, cost proposal, and DoD Company Commercialization Report) has been submitted electronically through the DoD submission site by 3:00 p.m. EST 17 April 2002.

____2. The Phase I proposed cost for the base effort does not exceed $70,000. The Phase I Option proposed cost does not exceed $30,000. The costs for the base and option are clearly separate, and identified on the Proposal Cover Sheet, in the cost proposal, and in the work plan section of the proposal.

NAVY FY02 STTR TITLE INDEX

N02-T001	Artificial Muscle Technology
N02-T002	Pocketable Language Translation System for use in Noisy Environments
N02-T003	Securing And Fendering For Skin To Skin Replenishment
N02-T004	Flexible Solar Cells Using Biotech Materials Processing
N02-T005	Improved Head-Mounted Displays for Immersive Virtual Reality
N02-T006	Speech Interface Architecture For Human To Agent Interactions
N02-T007	Efficient Compact Bio-inspired Sensory Information Processing
N02-T008	Advanced Rope Materials
~~N02-T009~~	~~Technologies to Support RO/RO Cargo Transfer in Sea State 5~~ **DELETED**
N02-T010	Biology-Based Electro-Magnetic Underwater Navigation
N02-T011	Non-cooperative Coded Marking of Vehicles or Personnel
N02-T012	Ultra-wideband Sensor Web
~~N02-T013~~	~~Enabling Hull Structural Innovations for High-Speed Lighters~~ **DELETED**
N02-T014	Autonomous Underwater Sensing of Weapons of Mass Destruction (WMD)
N02-T015	Real-time Multimedia Communications in Highly Mobile Networks.
N02-T016	Reinforcement Learning and Genetic Learning Classifier Systems for Sensor Management and Adaptive Flight Control System
N02-T017	Real-Time Supervisors and Monitors for Performing Health Monitoring and Fault Detection for Systems Operating in Multiple Regimes
~~N02-T018~~	~~Compact Actuator System~~ **DELETED**
~~N02-T019~~	~~Active Cooling of High Heat Electronic Components~~ **DELETED**
~~N02-T020~~	~~Low Drag Multi-Frequency Radome~~ **DELETED**

NAVY STTR FY02 TOPIC DESCRIPTIONS

N02-T001 TITLE: Artificial Muscle Technology

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop electro-active polymer technology for flexible underwater propulsor blades.

DESCRIPTION: Mammalian skeletal muscles have mechanical properties that conventional actuators do not posses. The properties are large linear strain, moderate stress, efficiency, power, cycle life and others. Synthetic organic chemistry advances are enabling the creation and manipulation of molecules that mimic natural mechanisms, which endow such properties [1 & 2]. Some key progress has been made. The present proposal topic seeks to develop the electro-active polymer muscle technology spectrum from molecular design engineering to the fabrication of representative underwater propulsor blades that dynamically flex as digitally programmed [3].

PHASE I: Define properties of flexible blades for Naval application. Identify key technology issues for Phase II. Conduct molecular design. Build sample muscles and demonstrate the key feasibility issues of Phase II.

PHASE II: Develop muscle technology. Demonstrate flexible blades working in a laboratory environment.

PHASE III: Develop technology farther. Design, fabricate and demonstrate a multi-bladed propulsor with several flexible blades for small underwater vehicles.

COMMERCIAL POTENTIAL: Would be useful to small boats, recreational and commercial water vehicles. Has tremendous general potential in industrial fluid pumping. Would make generic improvement in quiet pumping and low-energy consumption.

REFERENCES:
1. Yoseph Bar-Cohen, Ed., Electroactive Polymer Actuators as Artificial Muscles: Reality, Potential and Challenges, SPIE Press, Bellingham WA, 2001.
2. J. D. Madden, P. G. Madden, I. W. Hunter, (and other articles on various types of artificial muscles) in Proceedings of SPIE 8th Annual Symposium on Smart Structures and Materials: Electroactive Polymer Actuators and Devices, Yoseph Bar-Cohen, Ed. (SPIE, Bellingham WA, 2001).
3. Bandyopadhyay, P. R., Krol, W., Nedderman, W. H. & Mojarrad, M. 2001 “A Biomimetic Propulsor for Active Noise Control: Experiments,” Proc. 12th Intl. Sympo. On Unmanned Untethered Submersible Technology, Workshop on Biorobotics, Aug. 27-29, 2001, Publ. by AUSI, NH.

KEYWORDS: Muscle; Polymer; Electro-active polymer; Molecular Design; Sensor-Measurement technology, Propulsor

N02-T002 TITLE: Pocketable Language Translation System for use in Noisy Environments

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Provide a prototype Pocketable Language Translation System that can identify keywords as they are spoken even though significant background noise and/or degradation of the audio signal (e.g., static) is present. This system will be used in Advanced Warfighter Exercises (AWE), Joint Technology Demonstrations (JTD), Advanced Concept Technology Demonstrations (ACTD) and/or Navy Concept Evaluation Programs (CEP) which are intended to evaluate emerging technologies to support Counter Terrorism activities.

DESCRIPTION: One of the desired capabilities in combating terrorism is the ability to rapidly interpret conversations being conducted in a foreign language. These conversations typically occur in situations where significant background noise is present. Because of the extremely poor signal to noise ratio that may be present, traditional speech recognition approaches will not suffice. A novel approach to recognize words that are being spoken in such an environment is needed. It is desired that the system be capable of recognizing all spoken words, however, it is acknowledged that such a system operating in the stated environment is not feasible at this time. To fill the immediate need in a timely manner, rather than achieving a near 100% recognition rate the system must be capable of identifying user specified keywords as they are spoken. Once such a conversation of interest is identified, other means can then be implemented to provide a translation of the complete conversation. To significantly increase the usefulness of the system, it needs to be field deployable. Thus, the computing platform must be ruggedized to shock, dust and water, be small in size, lightweight and have an extended battery life. Ideally, this device will include a touchscreen color display that is viewable in all lighting conditions including where direct sunlight is present, indoor conditions where room lighting is present and in the evening when minimal ambient light is present. Because stealth may be a crucial aspect of operations, the system must minimize any emissions of light. Strong importance needs to be given in designing the system to minimize the power consumption and thus maximize the life of the battery. Finally, the battery must be field replaceable.

PHASE I: Demonstrate a functional prototype version of the system outlined in the above description along with a design concept to ruggedize the unit for subsequent field testing.

PHASE II: Develop and fabricate the ruggedized version of the system and field test the unit in multiple operational environments.

PHASE III: Once the concept and technology are proven in an ATD, ACTD, AWE, or CEP, the system may be acquired for use in field exercises, actual operational deployments, or both.

COMMERCIAL POTENTIAL: A ruggedized hand-held computing system for use in Counter Terrorism activities will also support firefighters, emergency response operations and civilian law enforcement personnel as they conduct operations where non-native speakers may be present. The computing platform will also be applicable in many industrial settings where ruggidized computing systems are required. This includes applications such as delivery personnel, utility workers, construction sites, and many assembly/manufacturing facilities.

KEYWORDS: Language Translation, Speech Recognition, Counter Terrorism

N02-T003 TITLE: Securing And Fendering For Skin To Skin Replenishment

TECHNOLOGY AREAS: Ground/Sea Vehicles

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: Littoral Combat and Power Projection FNC, Expeditionary Logistics

OBJECTIVE: Devise methods of securing ships alongside each other, underway at slow speeds or at anchor, that prevent hull and superstructure damage while facilitating cargo transfer. Critical technologies include improved cargo motion control cranes, improved protective fendering, new ship securing technologies, fuel transfer adaptations, and surfactants. This is a new objective of the Navy, and these methods and technologies are not currently in use.

DESCRIPTION: Skin to skin alongside replenishment is common in commercial fleets, particularly among oil tankers which frequently have to transfer oil from larger vessels to smaller in order to reach port. Skin to skin replenishment is defined here as: ships connected to each other separated by no more than the distance of fendering or securing gear, underway at less than 10 knots, and transferring liquid or solid cargo deck to deck using cranes or other direct contact methods. The principal difficulty is to bring US Navy hulls together in any but the calmest seas without endangering the superstructures and masts. Skin to skin replenishment may be faster than traditional underway methods, allows for the handling of heavier weights, and can act as a supplement to traditional underway methods. It is critical to be able to control the motion of the cargo being transferred while compensating for the motion of the sea and ensuring that the vessels are safely and closely connected. This capability would increase the at-sea capabilities of Naval forces.

PHASE I: Study methods of conducting skin to skin replenishment, vessel motion alongside other vessels in up to sea state 5, and devise methods of mooring ships to each other with minimal separation while still ensuring the safety of both vessels.

PHASE II: Apply the studies from Phase I to specific classes of Navy ships and provide preliminary designs and hardware that would keep ships apart and together while conducting skin to skin replenishment. Scaled or modeled demonstrations, showing risk reduction and feasibility, are desired but not required.

PHASE III: The technology should be transitioned to shipbuilders for implementation on Navy and Commercial ships.

COMMERCIAL POTENTIAL: Designs would be applicable to any vessel that has need of being replenished at any site other than a pier, and would provide valuable flexibility to all vessels.

REFERENCES:
Skin to Skin Replenishment Additional Web Information
1. Traditional and Modern Fendering Systems: http://wmel32.respark.wsu.edu/FenderPres/

2. J.H. Menge & Company, Inc.: http://www.jhmenge.com/
3. Fenders, Moorings and Anchors: http://www.naval-technology.com/contractors/fenders/
4. EIRFLOAT Modular Pontoon System: http://www.eirfloat.cchosting.net/
5. Petroleum Place - Float Equipment: http://www.petroleumplace.com/BusinessDirectory/FloatEquipment/
6. Wind Waves and Surface Tension: http://earth.agu.org/revgeophys/rogers01/node4.html
7. Thin Films with High Surface Tension: http://epubs.siam.org/sam-bin/dbq/article/29284
8. Department of Ocean Engineering - Sealift Option for Commercial Viability (SOCV): http://www.hurricane.net/~chrism/sealift1.html
9. SEAHUB - The Next Step in InterModal Transportation: http://www.coastal-institute.org/seahub_wp.html
10. National Academy Press - Oil Spill Risks From Tank Vessel Lightering: http://www.nap.edu/books/0309061903/html/index.html

KEYWORDS: Logistics; Mooring; Fendering

N02-T004 TITLE: Flexible Solar Cells Using Biotech Materials Processing

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: Expeditionary Warfare Operations Technology - FNC

OBJECTIVE: Develop environmentally benign biotech processes for manufacturable photovoltaic materials as flexible all-solid state sheets that can be incorporated into fabrics (e.g. uniforms, tentage, camouflage netting, alice packs, and helmet covers) and used as solar cells to charge flexible secondary batteries (a known art). Such integrated solar cell/secondary battery configurations would be water-proof, light-weight, compliant, deployable and non-hazardous replacements for primary batteries. The greater military objective is to reduce the logistical footprint by prioritizing solutions which optimize smaller, lighter, and more reliable, energy-efficient and survivable options.

DESCRIPTION: Macrodye-sensitized nanocrystalline semiconductor-based solar cells are sought that have high photoelectric conversion efficiencies (e.g. ~5-10 %, corresponding to ~ 30 watts/meter2) and that are processable into thin films for use on flexible substrates. The scheme envisaged requires electron transfer from the excited state of the macrodye to the semiconductor particle (e.g. TiO2), reduction of the oxidized macrodye by the redox macroelectrolyte, and then regeneration of the macroelectrolyte through the external circuit. For environmental reasons, both the macrodye and the macroelectrolyte should be obtained through enzymatic/microbial or biomimetic polymerization.

PHASE I: Screen families of chromophoric monomers with desirable spectral properties and design efficient and scalable biopolymerization strategies for the synthesis of thermo- and photo-stable macrodyes. Characterize and evaluate these polymers as macrodye candidates. Similarly, devise enzymatic routes for the synthesis of polymeric redox electrolytes having suitable molecular weights, polarities, viscosities, glass transition temperatures and thermal stabilities, and characterize and evaluate these materials.

PHASE II: The Phase II deliverable will be the I-V characterization of a fabricated bench-top photovoltaic cell prototype incorporating a semiconductor (multi) layer and enzymatically synthesized macrodye and macroelectrolyte layers, with associated electrodes. Processing and layering optimization of these new materials will be required; particularly the dye-nanoparticle and macroelectrolyte components, and I-V characterization will utilize a solar simulator. Proof of scalable manufacturability will be established.

PHASE III: The expected transition will be reliable tactical electrical power to support operations on a digitized battlefield and to insure information dominance. Marine Corps Systems Command (MCSC) is the transitional sponsor.

COMMERCIAL POTENTIAL: Military applications for portable/wearable low power photovoltaic technology range from individual combat gear, camouflage systems and sheltering devices. Civilian uses include outdoor recreational applications and to power stand-alone remote sensors, displays, data logging and transmission.

REFERENCES:
1. Deb, S. K., Renewable Energy 15, p 467 (1998)
2. O'Reagan, B., Gratzel, M., Nature 353, p 373 (1991)
3. Dahmouche, K. et al., Solar Energy Materials and Solar Cells 54, p 1 (1998)

KEYWORDS: Flexible Solar Cells; Macromolecular Dyes and Electrolytes Through Bioprocessing; SiO2 Nanoparticles; Primary Battery Replacements; All-Solid State Sheets; Small Rugged Power Supplies

N02-T005 TITLE: Improved Head-Mounted Displays for Immersive Virtual Reality

TECHNOLOGY AREAS: Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: Capable Manpower FNC, VIRTE

OBJECTIVE: To develop a better head-mounted display (HMD) for immersive virtual reality systems for training close quarters battle (CQB) that has a wider field-of-view; higher resolution; better contrast, color, and linearity of display; good ergonomics, safety, and reliability; lighter weight; and low cost.

DESCRIPTION: VR technology offers a promising approach to providing a family of realistic, deployable, immersive simulators to train warfighters in the tactics, techniques, and procedures of CQB that are too dangerous, costly, or otherwise impossible to practice. An immersive simulator supports the real-time interaction of a person in a virtual environment. A virtual environment is an array of sensory cues generated in response a user's actions that gives the user the impression of dealing directly with a three-dimensional model of the virtual world. Key components of an immersive simulator are full-body tracking to capture the person's actions and an HMD that provides a three-dimensional surround view. The surround view provided by the HMD is critical for training the warfighter because the warfighter must rapidly respond to threats that can come from any direction, including from the top of a building or from behind. The HMD allows the user to look in any direction and is light enough to allow the user to turn the head quickly to meet the threat. The National Research Council [1] has recommended that the development of adequate head-mounted displays is very important to the field of VR. The authors list deficiencies in current HMD technology and suggest new technology that might improve the state of the art. Progress is being made in studying aspects of the problem [for example, 2, 3, 4, 5, 6], but to date, an adequate commercial product with the required field-of-view, resolution, stereo mode, and weight [7] is not available. Immersive simulators to train CQB need HMDs with better visual displays and ergonomics at low cost. The HMD should better approach the human field-of-view of 120 degrees by 120 degrees per eye. Field-of-view is critical to being able to navigate through a virtual world. The HMD should have a significantly higher resolution than 640 by 480. Contrast, lumination, and color should provide a crisp image that allows the warfighter to distinguish target indicators close to real world performance at a reasonable update rate. Stereo should be provided. The HMD should be less than two pounds. Good ergonomics should be observed and the user should be able to adjust the fit of the helmet for head size and interoccular distance to feel comfortable while running. A wireless HMD would be highly desirable but should not impact image quality. A tethered design with a video cable is acceptable.

PHASE I: Concept exploration resulting in a feasibility study which outlines currently available or new technologies, capabilities, or design approaches that could be used in the fabrication of an HMD possessing the above described attributes. Phase I will also include the delivery of a technical proposal that outlines a specific design approach. The design approach will include: a development plan, the specification of manufacturing technologies to be used, and the specification of performance capabilities and trade-offs. An early prototype of the new approach would be desirable.

PHASE II: Implementation of Phase I design in the building of an HMD capable of being tested in a VR environment. Data will be collected to verify performance capabilities and will be provided in a final system evaluation report. The final system evaluation report should include any recommendations addressing noted deficiencies to further improve performance.

PHASE III: Productize an HMD that implements all of the improvements demonstrated in the Phase II STTR effort. Transition the HMD to the VIRTE component of the Capable Manpower FNC for use in the immersive virtual reality systems for training close quarters battle (CQB) and to VIRTE's transition sponsors.

COMMERCIAL POTENTIAL: An improved HMD is applicable to other military applications, scientific visualization, and the entertainment and game industries. It can be used in the commercial training industry such as teaching airplane repair and mission preparation. It can be used for product design of commodities such as automobiles and to collect ergonomic data. It can be used in the communications industry for remote conferencing.

REFERENCES:

1. Virtual Reality: Scientific and Technical Challenges (1995). National Academy Press, Washington, DC.
2. Arthur, D. W. (2000). "Effects of Field of View on Performance with Head-Mounted Displays." Dissertation from the Department of Computer Science, University of North Carolina at Chapel Hill.
3. Melzer, J.E. and Moffitt, K., eds. (1997). Head-Mounted Displays: Designing for the User. McGraw-Hill Optical and Electro-Optical Engineering Series, New York.

4. Rolland, J.P. and Vassie, L. (2001). "Albertian Errors in Head-Mounted Displays: Choice of Eyepoint Location," Technical Report TR01-001 University of Central Florida.
5. Robinett, W. and Rolland, J.P. (1992). "A Computational Model for the Stereoscopic Optics of a Head-Mounted Display," Presence, 1,1, 45-62.
6. Watson, B.A. and Hodges, L.F. (1995). "Using Texture Maps to Correct for Optical Distortion in Head-Mounted Displays," Proceedings of IEEE VRAIS, 172-178.
7. Latham, Roy (1998). "Head-Mounted Display Survey," Real Time Graphics, 7,2, 8-12.

KEYWORDS: virtual reality; head-mounted display; simulation systems; immersive displays; stereo; optics

N02-T006 TITLE: Speech Interface Architecture For Human To Agent Interactions

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: Capable Manpower FNC, VIRTE

OBJECTIVE: Develop architecture approaches for optimum integration of speech recognition/synthesis technology into simulations with human-agent interactions which account for processing time delays and multi-person communications with interruptions.

DESCRIPTION: Years of quality research have addressed technology solutions for speech recognition and speech synthesis. To date however many of the application domains have been sequential dialogs between humans and agents (i.e. telephone operator where timing isn't a critical factor). In contrast, many of the proposed applications for military domains require a much more fluid interplay between human and agent entities. Research needs to address innovative networking architectures to integrate these speech interface technologies into dynamic, real-time, complex systems which rely on humans collaborating with synthetic entities, or agents, such as virtual reality training simulators and performance support systems.

PHASE I: Examine the state-of-the-art speech recognition/synthesis technologies, and architectures for networking combinations of speech interface technologies to address human- agent and agent-human communications in dynamic, real-time, complex systems which rely on humans collaborating with synthetic entities or agents such as virtual reality training simulators and performance support systems.

PHASE II: Develop a prototype speech interface for human-agent and agent-human interaction which accounts for processing time delays and multi-person/agent communications with interruptions.

PHASE III: A successful approach would be integrated into VIRTE Demo II and III, and the transition beyond.

COMMERCIAL POTENTIAL: Effective integration of speech recognition/synthesis is a critical simulation and automated performance support problem. In addition to military uses, emergency response, and disaster relief simulations would benefit.

REFERENCES:
1. J. Stokes: "Speech Interaction and Human Behavior Representations (HBRs)" Proceedings of the 10th Conference on Computer Generated Forces & Behavioral Representation, Orlando FL May 15-17, 2001.
2. http://www.sisostds.org/cgf-br/10th/view-papers.htm Identifier: 10th-CGF-025
3. S. Weinschenk and D. Baker: Designing Effective Speech Interfaces, Wiley. New York. 2000.

KEYWORDS: Human-Agent Interaction, Speech Recognition, Speech Synthesis, Synthetic Forces, Cognitive Agent, Virtual Reality

N02-T007 TITLE: Efficient Compact Bio-inspired Sensory Information Processing

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: The objective is to demonstrate and implement the advantages of innovative compact, efficient sensor systems for navigation and guidance on autonomous mobile platforms. The information processing systems for these platforms will be based upon recent progress in understanding of retinal function. Solutions will translate biological architecture and function into efficient algorithms and hardware.

DESCRIPTION: Compact, efficient image processing is essential for numerous tactical applications, including navigation and control of miniature UAV's, night vision systems, target identification and tracking, surveillance, air to ground targeting, airborne reconnaissance, search and rescue operations, piloting and navigation aids, maritime surveillance, missile seekers and many others. These applications require a high level of functionality, compactness, low power consumption, and robustness. These features are only be attainable by using, innovative electronics and algorithmic design.

Novel designs inspired by biological information processing systems allow creation of systems with improved capabilities and efficiency. For example, the vertebrate retina efficiently encodes information about movement, optical flow, while maintaining an extremely broad dynamic range and sufficient signal depth. These concepts can be translated into efficient hardware and algorithm design. Recent advances in the design of massively parallel analog silicon design can mimic retinal function using low precision components consuming little power, in a very small package.

Design concepts to be incorporated into the proposal should include: multi-spectral sensory information processing, real-time sensor fusion, massively parallel programmable or fixed-function devices, mixed-signal analog/digital computing arrays, compact, low power packaging. Proposals should incorporate biologically-inspired technologies for the solution of the applications outlined above. Priority will be given to proposals based upon small, low-cost, low-power modular robust systems and sensors.

PHASE I. Design concepts will be realized in a series of prototypes designed to satisfy specific missions as outlined above.

PHASE II. Additional prototype fabrication and testing will evaluate the advantages of the underlying design concepts as applied to specific mission areas as outlined above.

PHASE III. The design concepts and prototypes will be transitioned into both government and commercial programs.

COMMERCIAL POTENTIAL: Commercial applications include night vision and vision through fog and smoke, truck and auto navigation aids, commercial airline navigation and control, and others.

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1. Scribner, J.G. Howard, R. Klein, J. Schuler, P. (2001) Computing Optical Flow Using Neuromorphic Arrays Warren Naval Research Laboratory Washington D.C. Distribution authorization to U.S. Government agencies and their Contractors - Critical Technology, March, 2001. Other requests for this document shall be referred to Naval Research Laboratory, Code 5630, 4555 Overlook Avenue, S.W., Wash., D.C. 20375-5000

KEYWORDS: Sensors, Image Processing, Massively Parallel Processing, Surveillance, Guidance, Target Recognition, Navigation, Optical Flow, Bio-inspired design.

N02-T008 TITLE: <u>Advanced Rope Materials</u>

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: Littoral Combat and Power Projection FNC, Expeditionary Logistics

OBJECTIVE: To develop new materials and/or manufacturing techniques to provide high strength, light weight, high flexibility rope for running rigging that has a high abrasion resistance and low maintenance.

DESCRIPTION: Wire rope is commonly used in many applications due to its high strength, high abrasion resistance and low cost. However, wire rope is very heavy and very inflexible, particularly large diameter wire ropes. Technical information on current wire rope applications may be found in the References listed below. New materials and/or manufacturing methods that improve the strength to weight ratio of ropes would significantly aid in handling and rigging for ropes over ¾" diameter. Any new rope technology would have to be at least as strong as an equivalent diameter wire rope and should be low stretch like wire rope. The new rope should not be susceptible to long term creep. Heat buildup generated using the rope as running rigging should not cause degradation in properties. Current high strength synthetic ropes have a lower abrasion resistance than wire and therefore require that sheaves or other turning surfaces be highly polished.

PHASE I: Conduct a preliminary study that would identify potential material and/or process improvements that would improve rope handling and rigging, abrasion resistance and temperature sensitivity.

PHASE II: Begin to develop new large diameter, high strength rope that meets the criteria. Identify materials and process to develop the rope. Producibility and affordability concerns should be addressed. The rope is to be tested.

PHASE III: ExLog component of the Littoral Combat and Power Projection FNC will work with the appropriate NAVSEA and OPNAV acquisition codes to facilitate transition of the technology.

COMMERCIAL POTENTIAL: New rope materials would have many potential commercial applications. Commercial shipping companies are transitioning to synthetic mooring lines due to the ease in handling. Mining applications would likely be interested in new rope technologies. Crane manufacturers would also be interested in advanced rope technologies.

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1. ASTM A1007-00, Standard Specification for Carbon Steel Wire Rope.
2. Naval Ship Technical Manual S9086-UU-STM-010, Chapter 613. This may be downloaded from http://braddock.com/library/nstm

KEYWORDS: Logistics; Cargo; manpower; rope, mooring, UNREP

N02-T009 TITLE: Technologies to Support RO/RO Cargo Transfer in Sea State 5

DELETED

N02-T010 TITLE: Biology-Based Electro-Magnetic Underwater Navigation

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop a biology-based Electro-Magnetic navigation system for underwater use.

DESCRIPTION: The geo-positioning satellite (GPS) system is not available underwater. Due to this reason, an autonomous underwater vehicle (AUV), for example, while mapping a sea floor needs to come up to the surface to re-calibrate its position with the GPS system at regular intervals after it has traveled some distance. The present proposal topic seeks to find an alternative, so that the frequency of calibration is reduced. The topic proposes that the Lorenz force based navigation system found in certain aquatic animals be mimicked in an engineering instrument. The Navy mapped magnetic field of sea floor could be referenced. A passive low-power system is preferable.

PHASE I: Study and distill the Lorenz force based navigation superiority of appropriate aquatic animals suitable for engineering replication. Carry out engineering design for passive low-energy application. Demonstrate and simulate key aspects of technological road map in a bench top format. Provide Phase II industrial development plan.

PHASE II: Carry out engineering development of sensor and measurement technology. Demonstrate in laboratory on a Navy representative vehicle and field setting to the extent feasible. Technology should be amenable to typical Navy vehicles.

PHASE III: Conduct field tests and demonstrate the Lorenz force based navigation system in underwater Navy field settings on a Navy representative vehicle.

COMMERCIAL POTENTIAL: If sufficiently miniaturized, with MEMS (Micro-Electro Mechanical System) technology for example, the navigation system could be attached to diving suits. Could be useful to offshore oil industry. Could be a fallback to GPS.

REFERENCES:

1. "Detection of magnetic inclination angle by sea turtles: A possible mechanism for determining latitude," Lohmann-Kenneth-J; Lohmann-Catherine-M-F, Journal-of-Experimental-Biology. 1994; 194 (0) 23-32, 1994.
2. "Magnetic orientation of spiny lobsters in the ocean: Experiments with undersea coil systems," Lohmann-Kenneth-J., Pentcheff-N-Dean, Nevitt-Gabrielle-A, Stetten-George-D, Zimmer-Faust-Richard-K, Jarrard-Hugh-E, Boles-Larry-C, Journal-of-Experimental-Biology, 198 (10) 2041-2048, 1995.
3. "Magnetoperception of some tissues of the pink salmon during migration", Zagal'-skaya-E-O, Zhurnal-Evolyutsionnoi-Biokhimii-i-Fiziologii; 30 (5) 662-666, 1994. In Russian.

4. “Detection of weak electric fields,” Kalmijn, Ad. J. 1988 Chapter 6, 151-184, of Atema, Jelle, Fay, Riehard, R., Popper, A. N. & Tavolga, W. N. (eds), Sensory Biology of Aquatic Animals, first edn., New York: Springer-Verlag.

KEYWORDS: Magneto-perception; GPS; Shark; Sea Turtle; Underwater Navigation; Lorenz Force.

N02-T011 TITLE: Non-cooperative Coded Marking of Vehicles or Personnel

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: Littoral Combat and Power Projection Future Naval Capability (FNC)

OBJECTIVE: The objective of this topic area is to develop new tools which would assist a USMC combat unit in reducing an adversary’s ability to hide among an indigenous population, displaced refugees or friendly coalition forces in an urban or confused battlefield environment. Technical approaches may include the use of organic or inorganic substances, particles, fibers, microscopic structures or devices that adhere to a marked entity and either passively or actively contrast it from unmarked entities. Mandatory attributes include real time detection of markers and the use of coding to correlate markers to specific operations, locations or dates. Operational simplicity and robustness are also desirable, however it is likely that the practical applicability of many tools will be highly scenario dependent. For example, it is probable that certain technologies will only be appropriate for use at highly controlled fixed checkpoints whereas others may be employed at line-of-sight distances. Technologies may also prove useful for enhancing the targeting of enemy forces on the battlefield.

DESCRIPTION: Future USMC operations are likely to place Marines among large local indigenous populations, either in an urban environment or among displaced refugees. In a confusing sea of humanity, anonymity can be a powerful tool for concealing hostile forces and activities. The intent is to infringe on an enemy’s use anonymity and concealment. Opportunities for exploiting recent advances in various forms of spectroscopy (remote and otherwise) together with recent advances in the fabrication of microscopic particles, layered materials, encapsulated materials, whiskers and fibers with uniquely tailored signatures may provide an opportunity for new marking and detection capabilities. The challenge will likely be to extend concepts that are currently feasible in laboratory environments to practical field applicability.

PHASE I: This phase would refine the proposed concept to the point where system performance capabilities and limitations could be reasonably predicted, and system design trade-offs could be quantified.

PHASE II: This phase would fabricate laboratory breadboard experimental prototypes of both markers and appropriate detection equipment, and demonstrate them in a laboratory setting which simulates the anticipated key issues associated with field use.

PHASE III: Phase III would consist of a simulated operational demonstration as part of a USMC field exercise.

COMMERCIAL POTENTIAL: Law enforcement, Wildlife tagging and monitoring

KEYWORDS: Tagging, Marking, Tracking, Forensics

N02-T012 TITLE: Ultra-wideband Sensor Web

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: Littoral Combat and Power Projection FNC; Knowledge Superiority and Assura

OBJECTIVE: This effort will explore the feasibility of a disposable battlefield sensor web based on a fusion of ultra-wideband radio and radar for (1) establishing relative location of individual sensors, (2) calibration of the sensor field, (3) mono-static and multi-static sensing of personnel and/or vehicles and (4) communicating and relaying sensor information. The research task effort will investigate the extent to which the above four items can be achieved using common electronics, common waveforms and common transmission/reception protocols.

DESCRIPTION: Distributed disposable ground based motion sensors are likely to play an increasingly important role for future maneuvering land forces. Primary applications will likely include reconnaissance as well as perimeter and flank security. Numerous electro-optical and acoustic sensing technologies are currently being pursued within the DoD. Various network designs are also being pursued for communicating with distributed sensors. However, the multiplicity of tasks required of individual sensor units has tended to require relatively sophisticated devices. As an alternative, it may be possible to produce an extremely low cost device by choosing an RF waveform (and implementing electronics) inherently capable of multiple functions. A fusion of two relatively new technologies may offer the possibility of producing a very low cost, low power RF sensor with both inherent Low Probability of Intercept/Low Probability of Detection (LPI/LPD) communication and accurate relative positioning capabilities. Ultra-wideband radio and micro-power impulse radar are two applications of a similar technology. Both are by-products of recent advances in high-speed digital circuitry. Both transmit, receive and measure the timing between short (nominally nanosecond) impulses. Both are also short-range in nature and both are highly affected by objects in the propagation path. It may be practical to fuse these similar concepts into a single device using common electronics and waveforms for position determination, sensor calibration, sensing and communicating. An array of such sensors dispersed over an area could conceivably operate in many combinations of mono and/or multi static modes, providing high-density coverage as well as orthogonal sensing directions. Each sensor could also conceivably either communicate its status directly or via other sensors, depending on ranges and relative placement. Relative positioning information provided by such a sensor array would in most circumstances be accurate to within 1 foot (1 nanosecond), without GPS. The feasibility of consolidating recent developments in this area toward producing a low-cost disposable sensor web could ultimately provide the USMC with a simple, inexpensive and versatile tool for reconnaissance, situational awareness, and area denial.

PHASE I: This phase will investigate initial feasibility by quantifying overall system design paramaters and key tradeoffs. The overall system design will address issues such as practical detection limitations for mono and bistatic modes, practical communication ranges, communication link redundancy, power consumption, sensor placement density, sensor unit cost, sensor timing synchronization (as required), concepts for analysis and display of monostatic and multistatic sensor web information, and other issues pertinent to the specific proposed approach. At the end of this phase it should be possible to estimate the feasibility of further pursuit via experimentation.

PHASE II: Phase II would begin by refining and validating the design concepts of phase I with specific experimentation, and would complete with a series of breadboard experiments which demonstrate the capabilities of a small number of individual sensor units to achieve the four functions in the objective (above). This phase would clearly define any issues to be resolved prior to fabrication of a fully populated sensor network.

PHASE III: This phase would involve fabrication and field testing of a sensor web prototype of representative coverage and density. The objective would be to demonstrate the feasibility of the concept to the extent necessary for the USMC to make a decision on pursuing product engineering refinements and manufacturing development.

COMMERCIAL POTENTIAL: Security monitoring of homes or buildings.

KEYWORDS: Ultra-wideband Radio, Ultra-wideband Radar, Impulse Radar, Sensor Web, Micropower Impulse Radar

N02-T013 TITLE: Enabling Hull Structural Innovations for High-Speed Lighters

DELETED

N02-T014 TITLE: Autonomous Underwater Sensing of Weapons of Mass Destruction (WMD)

TECHNOLOGY AREAS: Chemical/Bio Defense

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMS-EOD (Explosive Ordnance Detection)

OBJECTIVE: This effort will develop an underwater surveillance system to monitor the water column, the air near the water's surface, and shallow bottom sediments for evidence of the presence of weapons of mass destruction. The sensors suite will be employed on a currently fielded small autonomous underwater vehicle, and will comprise sensors for radiation, chemical agents (and related industrial chemicals) and biological warfare agents.

DESCRIPTION: It is the goal of this project to develop a system with the ability to sense the water column and the air immediately above the water surface for the presence of chemical and biological warfare agents, and related industrial chemicals or by-products of synthesis. These analyses will be conducted in real time within the payload bay of an underwater platform. In addition, the system will retrieve water, air, and sediment samples for post-mission analysis for chemical and biological warfare agents. The autonomous underwater vehicle (AUV) to be used as a platform is the Remote Environmental Monitoring UnitS (REMUS), a version of which is currently fielded in the SPECWAR community as the SHARV vehicle. The REMUS platform is small (about 6 ft in length with a 6"diameter nose cone, 80 lbs in weight) and easily operated by a trained two-man team. A current ONR program, Chemical Sensing in the Marine Environment, utilizes this vehicle as a platform for underwater explosive sensors. The REMUS system can operate typically at 2 meters/sec, at depths of 0 –30 meters, has a range of 110 km, and a run time of 22 hours per battery charge.

PHASE I: Design an AUV payload subsystem to sample and pre-concentrate chemical and biological agents from marine waters and from the air within 0.5 m of the surface, and to present these samples to appropriate on-board sensors for on-board analysis. Design a sample retrieval subsystem that will collect air, water, and bottom sediment samples and preserve and return them for after-mission analysis for the presence of chemical and biological warfare agents and for the presence of radiation. Both subsystems must meet operable temperature range, weight, size, and power requirements, making them appropriate for use in a REMUS AUV.

Consider currently available or late prototype chemical, biological, and radiation sensors, and select one or more for use with the designed sampling subsystem. Determine what constraints the sampling system design puts on the type of sensor or analysis system selected. Demonstrate the feasibility of the sampling and sample retrieval subsystem design using a bench top breadboard system. Based upon this design and currently available compatible chemical, biological, and radiation sensors, predict the lower detection limit and time response for analytes of interest expected from an integrated WMD sensor system.

Conclude Phase I by producing a design for a prototype integrated WMD analysis system suitable for a REMUS payload, and provide technical justification for sampling, sample retrieval, and sensor choices for the design. Suggest the most appropriate available post-mission analysis system compatible with the sample retrieval subsystem.

PHASE II: Fabricate a prototype integrated underwater sampling and sample retrieval system suitable for the autonomous sensing of WMD, based upon the design produced in Phase I. Select appropriate chemical and biological sensors, and conduct laboratory-based tests of the prototype integrated system to measure the lower detection limits and time response for the analytes of interest from water and air samples. Integrate the prototype sampling and sensor systems as a working payload for a REMUS vehicle. Participate in field tests with an appropriate on-going ONR program with the prototype system in REMUS to demonstrate the ability to effectively sample and quantify WMD signatures from artificially generated sources in water, air, and sediments. Modify the design of the system based upon field test results, and design a follow-on integrated WMD sampling, analysis, and sample retrieval payload for the REMUS vehicle.

PHASE III: Produce a turnkey integrated REMUS payload for underwater sampling and analysis, and for water, air, and sediment sample retrieval of WMD signals of interest for transition to Navy's COMNAVSPECWARCOM.. Provide working system, personnel training, and test and evaluation support for testing this system in Joint Exercises in FY 06-08.

COMMERCIAL POTENTIAL: There are numerous private-sector applications for an underwater sampling and analysis system in areas such as environmental quality as it pertains to state and government regulations, and in line quality assurance monitoring of industry plant water discharge. A major dual-use opportunity for the autonomous WMD sensing system will be to support Defense Treat Reduction Agency programs, and Homeland Defense projects, aimed at locating weapons of mass destruction in and around public areas as part of counter-terrorism efforts.

REFERENCES:
1. Ward, K.B., A. Ervin, J.R. Deschamps, and A.W. Kusterbeck, "Force Protection: Explosives Detection Experts Workshop ", NRL/MR-MM/6900--01-8564, CDROM. (2001).
2. McGill, R A et al, "The NRL-SAWRHINO" Sensors and Actuators. B, Chemical. 65, no. 1, (2000)10-13.
3. R.A. McGill, et al; "Performance Optimization of Surface Acoustic Wave Chemical Sensors"; IEEE Trans. on Ultrasonics, Ferroelectrics and Freq. Control. 45(5), 1370 (1998).
4. Whelan, James P. and Kusterbeck, Anne W. "Continuous-Flow Immunosensor for Detection of Explosives." Analytical Chemistry, v.65(24):3561-5, Dec 15.
5. Purcell, M., Von Alt, C., Allen, B., Auatin, T.,and Forrester, N. "New capabilities of the REMUS Autonomous Underwater Vehicle", Conference Proceedings, OCEANS 2000 MTS/IEEE, September 11-14, 2000, Providence, RI. ISBD # 0-7803-6554-2.

KEYWORDS: Detection of chemical/biological warfare agents; Weapons of mass destruction; autonomous underwater vehicles; Homeland Defense; Expanded littoral battlespace; Special operations.

N02-T015 TITLE: Real-time Multimedia Communications in Highly Mobile Networks.

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: The objective of this project is to develop innovative technologies to support reliable, time-critical exchange of information, e.g., voice, video, image and other types of data in a robust/jam resistant communications network whose members are in continual motion (this is a key point in so far as considering a fully mobile network as opposed to the cellular systems of today which have fixed base stations and mobile users). These new technologies will enable the exchange of critical command and control information without centralized facilities that increase system vulnerability and without endangering system security.

DESCRIPTION: Unmanned air vehicles (UAV's) are to be used as communication nodes for establishing a fully-mobile-reconfigurable communication network for intelligence, surveillance, reconnaissance, and strike support. The goal is to develop technologies and methods to rapidly configure and manage these networks so that they can share and disseminate critical data in real-time and to ensure that time-delay, jitters, and reliability requirements are all met. Technologies to be developed for real-time configuration and maintaining network connectivity include clustering of nodes to guarantee connectivity and preventing congestion, positioning relay points, frequency management, mobile routing, quality of service, managing hand-over during topology changes, security, multicasting, and addressing. Wireless ATM is currently under investigation for commercial mobile multimedia communications networks.

PHASE I: Conduct a feasibility and tradeoff study for dynamic mobile network configuration, and information and control architectures. Investigate techniques and procedures for efficient communication protocols, interfaces, and communication control systems and algorithms for time critical, reliable, and real-time multimedia data transfer.

PHASE II: Design, develop, and test a protocol suite for controlling real-time dynamic multimedia communications networks and message trafficking via air, satellite, sea, and land-based nodes. Design, develop, and test methods for real-time initial configuration of these networks. Evaluate quality--connectivity--performance with network simulation.

PHASE III: Implement protocols designed and tested in Phase II in a scaled commercial network.

COMMERCIAL POTENTIAL: Personal Communications Networks, Fleet Management, Emergency Services, Wireless ATM.

REFERENCES:
1. K. Pahlavan & A. H. Levesque "Wireless Information Networks", John Wiley and Son, 1995
2. K. Pahlavan & A.H. Levesque, "Wireless Data Communications", Proc. IEEE: Special Issue on Wireless Networks for Mobile & Personal Communications, September 1994
3. C.K. Toh, "Wireless ATM & Ad Hoc Networks: Protocols & Architectures", Kluwer Academic Publishers, January 1997, ISBN 0-7923-9822-X
4. M.M. Khan, "The Development of Personal Communication Services under the Auspices of Existing Network Technologies",IEEE Communications Magazine, Mar 1997,Vol. 35,No.3 pp. 78-82.
5. Mark Taylor, William Waung & Moshen Banan, "Internetwork Mobility - The CDPD Approach", Prentice Hall, 1997

KEYWORDS: Multimedia; Communication; Mobile; Networks; ATM; Connectivity

N02-T016 TITLE: Reinforcement Learning and Genetic Learning Classifier Systems for Sensor Management and Adaptive Flight Control System

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop methods to use reinforcement learning systems and genetic learning classifier systems for control and allocation of sensor resources and adaptive flight control system.

DESCRIPTION: Reinforcement Learning (RL) methods are novel combinations of dynamic programming (DP) methods, stochastic approximation methods, and learning methods. Learning classifier systems (LCS) are ruled-based machine learning systems that use genetic algorithms (GAs) as their primary rule discovery mechanism. LCS methods allow global optimization and can be used to solve DP problems.

Sensor management involves the selection and adaptive allocation of sensors, sensor modes, and sensor parameters to maximize their collective effectiveness for mission requirements. Sensor management systems for tactical air vehicles have been constructed using a variety of ad hoc methods. Most often these systems employ rule-based approaches and rely on the operator to make many real time deployment decisions. The objective is to formulate the problem of sensor resource control and allocation within a mathematical programming framework and use RL to develop an optimal sensor management system. The applications of RL and LCS to adaptive flight control systems hold promise in several areas, for example:

- Air combat and evasive maneuvers;
- Mission planning and replanning against dynamic threats;
- Multiple unmanned air vehicle flight formation and engagement;
- Trajectory control for weapon delivery;
- Gain scheduling for nonlinear control systems;
- Sequential input design for adaptive parametric systems identification.

PHASE I: Determine the scientific and technical merit and feasibility of the application of reinforcement learning to sensor management, sensor allocation, and adaptive flight control.

PHASE II: Use reinforcement learning systems to optimally manage and allocate sensor resources and demonstrate use of optimization algorithms for adaptive flight control.

PHASE III: Develop a road map for making these capabilities operational and ready for transition. Demonstrate real-time performance.

COMMERCIAL POTENTIAL: These technologies will be applicable to commercial avionics systems, and control and decision-making systems. The technology developed will provide greater integration at the system level, more affordable configurations, more efficient and supportable flight control architectures, and the ability to operate air vehicles safely and effectively in an inter-netted environment. All commercial aircraft manufacturers, suppliers, and airline would benefit from this technology.

REFERENCES:

1. R. S. Sutton and A. Barto, "Reinforcement Learning: An Introduction", MIT Press 1998.
2. L.P. Kaebling, M. L. Littman, and A. W. Moore, "Reinforcement Learning: A Survey", Journal of Artificial Intelligence Research, Volume 4, 1996, pp. 237-284.
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4. S.W. Wilson, "Classifier fitness based on accuracy", Evolutionary Computation, 3(1), 1995, pp. 149-176.

KEYWORDS: Reinforcement; Genetic; Learning; Classifier; Sensor; Adaptive; Control

N02-T017 TITLE: <u>Real-Time Supervisors and Monitors for Performing Health Monitoring and Fault Detection for Systems Operating in Multiple Regimes</u>

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Develop a real-time monitor and supervisor that would have the following capability:
- Robust health monitoring and fault detection strategies for air vehicles operating in multiple regimes;
- Real-time dynamic performance and model validation;
- Real-time reconfiguration and resource management should an unanticipated event occur.

DESCRIPTION: Verifying performance and safety under all possible operating conditions for complex systems such as UAVs are very difficult because of unanticipated faults, or operational circumstances, or design omissions. It is critical to have an autonomous monitoring system that is capable of real-time diagnostics, fault detection, and resource management. This project will develop a real-time monitoring system and supervisor that would have the following capabilities:

- Real-time fault detection and model validation;
- Real-time performance prediction;
- Real-time reconfiguration and resource management and feedback design.

The proposed supervisor would have hierarchical structure with continuous as well as discrete controllers. The lower layer of the supervisor would continuously collect the data from various subsystems and perform the task of model validation and fault detection. The higher level of the supervisor would be involved in making decisions regarding reconfiguration, development of new control strategies/laws, and resource management. The model validation approach would be developed based on recent results from robust multi-variable control theory and would be designed to be robust with respect to unmodeled dynamic and prior statistical assumptions regarding faulty and normal dynamics. After a subsystem malfunction has been determined, the higher level supervisor would design new control laws and reconfigure the system based on the worst-case analysis which would be carried out using approaches developed in game theory and optimal control.

A health monitor/fault detector (HM/FD) for a system compares the states of the system with certain bounds known to be satisfied by a "healthy" system, and flags an alarm if these bounds are violated. More sophisticated algorithms are capable of classifying faults. One important assumption followed in the design of current HM/FD algorithms is the existence of one unique "healthy" operating regime, against which the running system is compared. Many practical systems however operate in different regimes. Typical examples are air vehicles, such as manned or unmanned aircraft or missiles. “Regime” means a region of state space, defined by bounds on certain state variables of interest, such as angle of attack, or speed. Dynamics of a system can change from one regime to the other, so if a system with an HM/FD algorithm designed to operate on just one regime, will flag as a fault when it switches to a different regime. This is clearly undesirable, and points to the need of HM/FD strategies capable of distinguishing between faults on a given regime and regime switching.

The proposed project will investigate HM/FD algorithms capable of operating on different regimes using gated networks. The goal is to design HM/FD algorithms, which work well on a certain regime. These local algorithms are labeled gated experts, and “adapt” their width to match the noise level in that regime. The motivation for using different experts in different regions is that they can individually focus on the particular subset of state variables relevant for that specific region. The gated experts are put together on a gated network, which learns to predict the probability of each expert.

PHASE I: Investigate the development of a real-time monitor and supervisor capable of real-time fault detection, performance prediction, model validation, real-time reconfiguration, feedback design, resource management should an unanticipated event occur, and gated networks combined with gated experts for designing HM/FD algorithms for systems operating in multiple environments. Investigate the applicability of these methods for health monitoring and fault detection on Air Vehicles operating on different regimes. The crucial test of the algorithm is to verify if it can distinguish between faults and regime switching.

PHASE II: Develop a prototype of an autonomous HM/FD system capable of operating well during the entire course of a flying procedure. Demonstrate its performance characteristics. Develop a commercialization plan, including descriptions of specific tests, evaluations, and implementations to be performed.

PHASE III: Carry out the commercialization plan developed in Phase II.

COMMERCIAL POTENTIAL: The resulting system will have broad applications in power industry, manufacturing, commercial aviation systems, and other areas.

REFERENCE:
1. R.A. Jacobs, M.I. Jordan, S.J. Nowlan, G.E. Hinton, “Adaptive mixtures of local experts”, Neural Computation, vol. 3, pp. 79-87, 1994

KEYWORDS: Reactive; Health; Monitoring, Fault; Detection, Multiple; Regimes

N02-T018 TITLE: <u>Compact Actuator System</u>

DELETED

N02-T019 TITLE: <u>Active Cooling of High Heat Electronic Components</u>

DELETED

N02-T020 TITLE: <u>Low Drag Multi-Frequency Radome</u>

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